PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 143766.4 DAB	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/IL 03/00199	International filing date *(day/month/year)* 11.03.2003	Priority date *(day/month/year)* 11.03.2002
International Patent Classification (IPC) or both national classification and IPC G11B7/005		
Applicant MEMPILE INC. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 10 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the International application

Date of submission of the demand	Date of completion of this report
10.09.2003	22.06.2004
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Hermann, R Telephone No. +49 89 2399-2543

Form PCT/IPEA/409 (Cover Sheet) (January 2004)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IL 03/00199

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1-16	as originally filed
3a, 3b	received on 24.05.2004 with letter of 24.05.2004

Claims, Numbers

1-51	received on 24.05.2004 with letter of 24.05.2004

Drawings, Sheets

1/6-6/6	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

   ☐ the entire international application,

   ☒ claims Nos. 40-51

   because:

   ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (specify):

   ☐ the description, claims or drawings *(indicate particular elements below)* or said claims Nos. are so unclear that no meaningful opinion could be formed *(specify)*:

   ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

   ☒ no international search report has been established for the said claims Nos. 40-51

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

   ☐ the written form has not been furnished or does not comply with the Standard.

   ☐ the computer readable form has not been furnished or does not comply with the Standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-39
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-39
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-39
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item III

The amended claims 40 - 51 based on claims 41 - 52 filed the 17.12.2003 need not be the subject of international preliminary examination since these claims relate to inventions in respect to which no international search report has been established (Rule 66.1(e) PCT), the reasons being:

- the features of claims 40 - 45 are taken from originally filed dependent claims 21 - 26 however without the limiting features of claim 20 depending directly on independent claim 1; and
- the features of claims 46 - 51 are taken from originally filed dependent claims 35 - 40 however without the limiting features of claim 34 depending directly on independent claim 28.

Re Item V

1. The following documents (D) are referred to in this communication; the numbering will be adhered to in the rest of the procedure:
   D1: US-A-6 009 065
   D2: US-B1-6 291 132
   D3: WO-A-01/73779
   D4: US-A-6 128 267
   D5: US-A-6 034 929

2. Independent claims 1 and 27 meet the requirements of novelty, inventive step and industrial application according to Articles 33(2) to 33(4) PCT.

2.1 The relevant prior art documents D1 and D2 each show a method and an apparatus to retrieve information form a three dimensional storage medium (cf. D1 figs. 1 - 3, col. 5 line 64 - col. 11 line 43; D2 figs. 9 - 14 and 18, col. 6 line 10 - col. 9 line 30). The subject-matter of independent claims 1 and 27 differs from the disclosure of the prior art documents in that *the information from the three dimensional medium is retrieved by detecting a non-linear optical response being related to a $\chi^{(n)}$ process, where n is greater than 2, by spatially separating the non-linear optical response from other light signals due to a propagation direction characteristic of the non-linear response satisfying phase matching conditions.* The subject-matter of independent claims 1 and 27 is novel as none of the prior art documents cited in the Search Report or acknowledged in the description discloses all of the features or method steps, respectively, of these independent

claims.

2.2 The documents D1 - D5 do not render any suggestion to the skilled person to construct a three dimensional information storage retrieval apparatus or the corresponding method as disclosed in independent claims 1 and 27 according to the further features of either of independent claims 1 and 27. Hence, the features concerning *the retrieval of information from the three dimensional medium by detecting a non-linear optical response being related to a $\chi^{(n)}$ process, where n is greater than 2, by spatially separating the non-linear optical response from other light signals due to a propagation direction characteristic of the non-linear response satisfying phase matching conditions* result from a step being non-obvious in view of the cited prior art documents in which no incentive is given to provide this specific structure and arrangement. Thus the method and the apparatus according to either of independent claims 1 and 27 involve an inventive step.

2.3 The subject-matter of independent claims 1 and 27 and is able to work, can be manufactured, and the method steps of independent claim can be carried out. Thus the subject-matter of claims and the method of claims is looked upon as being industrially applicable.

3 Dependent claims 2 - 26 and 28 - 39 define further advantageous and non-obvious variations of the method and the apparatus according to independent claims 1 and 27 and thus equally meet the requirements of novelty, inventive step and industrial application according to Articles 33(2) to 33(4) PCT (see paragraph 2 above).

4 Remarks:

4.1 Independent claims 1 and 27 of the present Application do not comply with the requirements of Article 6 PCT in that they are not clear, the reasons being:
- the vague formulation 'allowing for spatially separating' used in claims 1 and 27 leaves the person skilled in the art in doubt as to how the light separation necessary for the detection of the non-linear light is achieved; the statement in paragraph 2 above is based on a clear formulation (see the formulation in italics in paragraph 2 above) derivable from the description page 6 lines 17 - 21;

- the particular characteristic of the non-linear response of the three dimensional storage medium is the base for the information signal separation and detection; however, claim 27 does not clearly enough state that the medium must therefore be part of the claimed information retrieval apparatus; all other elements of claim 27 without the particular medium response are known form D1 and D2 (see paragraph 2 above).

4.2 Independent claims 1 and 27 and are not drafted in the two part form specified in Rule 6.3b) of the PCT.

4.3 The description does not disclose the invention as claimed (see Rule 5.1a) iii) PCT).

U.S. Patent No. 6,009,065 discloses an optical pickup providing 3-D reading of binary optical information from a multilayer fluorescent disk by means of fluorescent sites excitation. 2-D information at the separate layer is recorded by chemical transformation of a photosensitive material from one stable molecular form A (non fluorescent) to other stable molecular form B (fluorescent) via UV light illumination. Only one reading laser beam is focused to the desired layer, which induces fluorescence in the whole volume confined within conical surface of the focused beam. An active medium which posses the fluorescing properties is organized in a form of multilayer optical disc. Fluorescence at the wavelength different from the excitation wavelength is detected. The detected signal undergoes spectral, spatial and electronic filtration in order to extract signal from the noise fluorescence coming from all out-of-focus layers. Dichroic mirror and/or filter is utilized in the optical pickup to prevent the photo diode from the reading laser radiation.

U.S. Patent No. 6,291,132 discloses a method of manufacturing a fluorescent 3-D optical memory device implementing an active medium capable of storing information at high information density. The active medium is a material capable of existing in at least 2 isomeric forms. Transition from one form to another can be induced upon illuminating this material by a "writing" electromagnetic radiation having a first spectrum. At the same time the other isomeric form is capable of fluorescence upon illuminating this material by a "reading" electromagnetic radiation with a second spectrum. By virtue of illuminating with a radiation having the first spectrum, elemental cells are created within a medium material, containing substantially the same isomeric form, which can be either that form which is capable of fluorescence or the other one which is not. The information is stored within the medium as numerical values associated with the amount of one of the isomeric forms of active medium contained within elemental cells distributed within the active medium.

U.S. Patent No. 6,128,267 discloses an active tracking method for optical disk storage. According to this technique, laser light is focused in an accurate manner on selected tracks on an optical disk recording medium by means of an analysis of output electrical signals from a dithered light source. This results in the production of an electrical signal which is proportional to an amount by which the light source in the system is to be moved, relative to the tracks, in order to achieve desired tracking of the focused spot along a desired track on the medium.

U.S. Patent No. 6,034,929 discloses a system for creating, reading and writing on rotatable information storage media, and a method for multi-layer laser source positioning. According to this technique, a laser beam is split into two beams. The first beam is oscillatorily at a first frequency in a direction associated with control of beam focus within two or more layers of a rotatable information storage medium, that is, in a CD-ROM-like device. The second beam is oscillatorily varied at a second (different) frequency in a direction so that it moves back and forth across an edge of a reference track. Separate filters are used to examine the reflected light so as to simultaneously control positioning of the laser light source along two axes.

CLAIMS:

1. A method for retrieving information from a three dimensional storage medium, the method comprising:

using a three dimensional storage medium comprising an active medium capable of being in two states, wherein a data unit is represented by the ratio between the concentration of the first and second of said two states in a given volume portion of said medium and a data sequence is represented by a sequence of such data units;

irradiating said active medium with light as to concentrate light flux through a volume portion of said storage medium so as to generate in said volume portion a detectable non-linear optical response characteristic of said concentration ratio, the non-linear optical response being related to a $\chi^{(n)}$ process, where n is greater than 2, allowing for spatially separating the non-linear optical response from other light signals due to a propagation direction characteristic of the non-linear optical response satisfying phase matching conditions;

detecting said non-linear optical response to retrieve information stored in said volume portion; and

tracking a data sequence for retrieving said data sequence in a reproducible manner.

2. The method according to Claim 1, wherein the active medium includes stillbene derivatives, azobenzene derivatives, or mixtures thereof.

3. The method according to Claim 2, wherein the active medium is embedded in a supporting matrix.

4. The method according to Claim 3, wherein the active medium is doped into the supporting matrix.

5. The method according to Claim 3, wherein the supporting matrix is a polymer.

6. The method according to Claim 5, wherein the active medium is a monomer co-polymerized with the supporting matrix.

7. The method according to any one of Claims 3 to 6, wherein the supportive matrix is transparent to the light irradiated on it and to the light generated by the non-linear optical process.

8. The method according to any one of Claims 3 to 7, wherein the supportive matrix comprises polyethylene, polypropylene, polycarbonate, and/or poly-methylmetacrilate (PMMThe), and/or other transparent polymeric material.

9. The method according to any one of Claims 1 to 8, wherein the irradiated light is focused to a spot having a radius of the order of 30 μm of said irradiated light or less.

10. The method according to any one of Claims 1 to 9, wherein the intensity of the irradiated light is high enough for the generated signal to be independent thereon.

11. The method according to any one of Claims 1 to 10, wherein the non-linearly generated light is separated from other light signals that may exist in the environment by a filter, prism, monochromator or any other optical element known in the art.

12. The method according to any one of Claims 1 to 10, wherein the non-linearly generated light is separated other light signals that may exist in the environment by satisfying phase matching conditions.

13. The method according to any one of Claims 1 to 10, wherein the non-linearly generated light is separated from other light signals that may exist in the environment by phase sensitive detection, a low-noise amplifier, a lock-in amplifier, a box-cars, gated averaging methods or any electronic method known in the art.

14. The method according to any one of Claims 1 to 13, wherein the large flux in the volume portion from which information is retrieved is achieved by focusing two or more collinear light beams at said volume portion.

15. The method according to any one of Claims 1 to 14, wherein the large flux in the volume portion from which information is retrieved is achieved by intersecting two or more focused light beams, each of which is monochromatic.

16. The method according to any one of Claims 1 to 15, wherein the non-linear optical process is a multi photon fluorescence process.

17. The method according to Claim 16, wherein the non-linear optical process is a two-photon fluorescence process.

18. The method according to any one of Claims 1 to 15, wherein the non-linear process is selected from Coherent Anti-Stokes Raman Scattering (CARS), Degenerate Four-Wave Mixing (DFWM), Raman Induced Kerr Effect Spectroscopy (RIKES), and/or other four-wave mixing processes.

19. The method according to any one of Claims 1 to 18, wherein the data sequence is tracked via a tracking feedback signal for directing the light spot to a predetermined volume portion of the storage medium.

20. The method according to Claim 19, further including correcting tracking errors in the optical storage medium by:

(a) directing a reading spot that is nominally focused on to a track in the optical storage medium,

(b) continually moving the reading spot in axial and radial directions,

(c) receiving a signal having an amplitude which varies according to respective offsets from the track in radial and axial directions,

(d) using the received signal to determine a direction of a respective offset from the track in radial and axial directions, and

(e) adjusting a location of the reading spot accordingly.

21. The method according to Claim 20, wherein directing the reading spot includes directing at least two light sources whose volume of intersection constitutes the reading spot.

22. The method according to Claim 20 or 21, wherein moving the reading spot includes modulating a position of the reading spot with a cyclic function.

23. The method according to Claim 22, wherein the cyclic function is substantially sinusoidal.

24. The method according to any one of Claims 20 to 23, wherein receiving a signal includes:

i) reading a data signal with the reading spot,

ii) multiplying the data signal by a cyclic modulation signal to form a modulated data signal, and

iii) low pass filtering the modulated data signal.

25. The method according to Claim 24, wherein low pass filtering includes window integrating the modulated data signal.

26. The method according to any one of Claims 1 to 25, further including analyzing and processing detected signals and retrieving information therefrom.

27. An apparatus (100) for retrieving information from a three dimensional storage medium, the apparatus comprising:

a mount (202) for mounting thereon a three dimensional storage medium (102) comprising an active medium capable of being in two states, wherein a data unit is represented by the ratio between the concentration of the first and second of said two states in a given volume portion of said medium and a data sequence is represented by a sequence of such data units;

at least one source of coherent light (104, 106) for irradiating said active medium with light as to concentrate light flux through a volume portion of said storage medium so as to generate in said volume portion a detectable non-linear optical response characteristic of said concentration ratio, the non-linear optical response being related to a $\chi^{(n)}$ process, where n is greater than 2, allowing for spatially separating the non-linear optical response from other light signals due to a propagation direction characteristic of the non-linear optical response satisfying phase matching conditions;

a filter (152) accommodated in an optical path of light coming from the medium to separate the non-linear optical response from other light signals

a detector (120) for detecting said non-linear optical response to retrieve information stored in said volume portion; and

a tracking unit (125) for tracking a data sequence for retrieving said data sequence in a reproducible manner.

28. The apparatus according to Claim 27, wherein said non-linear optical response is characterized by predetermined wavelength, polarization, or both of these characteristics.

29. The apparatus according to Claim 27, wherein the at least one source of coherent light includes an active light source.

30. The apparatus according to Claim 29, wherein the active light source is a laser.

31. The apparatus according to Claim 27, wherein the at least one source for coherent light includes a passive light source.

32. The apparatus according to any one of Claims 27 to 31, further including an algorithmic error detector (128) for analyzing and processing detected signals and retrieving information therefrom.

33. The apparatus according to any one Claims 27 to 32, wherein the tracking unit (125) is adapted for tracking the data sequence via a tracking feedback signal for directing the light spot to a predetermined volume portion of the storage medium.

34. The apparatus according to Claim 33, wherein the tracking unit (125) includes a tracking error correction unit for correcting tracking errors, the error correction unit comprising:

a position modulator (332) for modulating a position of the reading spot,

an error determination unit (333) for receiving a data signal having an amplitude which varies according to respective offsets from the track in radial and axial directions, and is responsive to the data signal to determine a direction of a respective offset from the track in radial and axial directions, which offsets may be fed to the optical unit to correct radial and axial position errors of the reading spot.

35. The device according to Claim 34, wherein the reading spot is a volume of intersection of at least two light sources focused on the track.

36. The device according to Claim 34, wherein the position modulator is adapted to modulate a position of the reading spot with a cyclic function.

37. The device according to Claim 36, wherein the cyclic function is substantially sinusoidal.

38. The device according to any one of Claims 34 to 37, wherein the error determination unit includes:

a multiplier (340) for multiplying the data signal by a cyclic modulation signal to form a modulated data signal, and

a low pass filter (341) for low pass filtering the modulated data signal.

39. The device according to Claim 38, wherein the low pass filter is a window integrator (341).

40. A method for correcting tracking errors in an optical storage medium having multiple tracks arranged in different layers of the optical storage medium, the method comprising:

(a) directing a reading spot that is nominally focused on to a track in the optical storage medium,

(b) continually moving the reading spot in axial and radial directions,

(c) receiving a signal having an amplitude which varies according to respective offsets from the track in radial and axial directions,

(d) using the received signal to determine a direction of a respective offset from the track in radial and axial directions, and

(e) adjusting a location of the reading spot accordingly.

41. The method according to Claim 40, wherein step (a) includes directing at least two light sources whose volume of intersection constitutes the reading spot.

42. The method according to Claim 40 or 41, wherein step (b) includes modulating a position of the reading spot with a cyclic function.

43. The method according to Claim 42, wherein the cyclic function is substantially sinusoidal.

44. The method according to any one of Claims 40 to 43, wherein step (c) includes:

i) reading a data signal with the reading spot,

ii) multiplying the data signal by a cyclic modulation signal to form a modulated data signal, and

iii) low pass filtering the modulated data signal.

45. The method according to Claim 44, wherein step (iii) includes window integrating the modulated data signal.

46. An error correction device for correcting tracking errors in an optical storage medium having multiple tracks arranged in different layers of the optical storage medium that are read by a focused reading spot directed by an optical head to a track in the optical storage medium, the error correction device comprising:

a position modulator for modulating a position of the reading spot,

an error unit for receiving a data signal having an amplitude which varies according to respective offsets from the track in radial and axial directions, and is responsive to the data signal to determine a direction of a respective offset from the track in radial and axial directions, which offsets may be fed to the optical head to correct radial and axial position errors of the reading spot.

47. The device according to Claim 46, wherein the reading spot is a volume of intersection of at least two light sources focused on the track.

48. The device according to Claim 46 or 47, wherein the position modulator modulates a position of the reading spot with a cyclic function.

49. The device according to Claim 48, wherein the cyclic function is substantially sinusoidal.

50. The device according to any one of Claims 46 to 49, wherein the error unit includes:

a multiplier for multiplying the data signal by a cyclic modulation signal to form a modulated data signal, and

a low pass filter for low pass filtering the modulated data signal.

51. The device according to Claim 50, wherein the low pass filter is a window integrator.